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(54) IMPROVEMENTS IN OR RELATING TO APPARATUS FOR THE BIOLOGICAL TREATMENT OF WASTE WATER BY THE BIOSORPTION PROCESS

(71) We, AMES CROSTA MILLS & COMPANY LIMITED, a British Company of Moss Iron Works, Heywood, in the county of Lancaster, and FRANK SANDERSON, a British subject of 5 Spring Bank Lane, Norden, Rochdale, in the county of Lancaster do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to apparatus for the biological treatment of waste water by the so-called 'biosorption' process in which its organic content is removed by the progressive action of micro-organisms present therein.

More particularly, the invention is concerned with apparatus of the type in which the aforesaid biological action is stimulated by the slow rotation, about a substantially horizontal axis, of a surface partially submerged in the liquid under treatment so that bacterial organisms progressively adhere to such surface as a slime which is alternately exposed to the air and re-immersed in the liquid.

As the thickness of this slime layer builds up, it periodically becomes too heavy for continued adhesion and drops off, or alternatively the surface may be mechanically scraped at intervals, the organisms thus released from the surface being deposited as sludge for removal or re-use in preliminary treatment of the liquid.

The present invention provide apparatus for the biological treatment of waste water by the biosorption process, comprising a rotor for partially immersing in the waste water so that bacterial organisms from the water adhere to the surface of the rotor and are therefore, with rotation of the rotor, alternately exposed to air and re-immersed in the water, wherein said rotor is structured to provide a plurality of closely spaced discs, having a cellular surface, for the adherence of said organisms.

The cellular surface may be derived from perforation produced by punching, expanding, or moulding, and the discs may be of circular, polygonal or other regular profile and may be either flat, dished or corrugated.

The rotor discs may be formed of metal, synthetic plastics, asbestos, felt, rubber or porcelain, depending upon the configuration to be adopted, and such material, accordingly as its nature permits, may be perforated, over the whole or part of its surface. The discs may be pierced or punched with a regular or irregular arrangement of holes or slots of any shape, it being convenient to use the so-called 'expanded metal' technique whether the material is metallic or otherwise. The discs may be also formed of a material such as felt, expanded rigid or flexible polystyrene, rigid or flexible, open or closed cell foamed plastics material or the like provided that, if the material is not self supporting it is held tensioned by rigid rims or other frames or alternatively, and for example in the case of a foamed or expanded material or a felt it is of such density as to be self supporting.

Alternatively, the discs may be formed by casting or moulding, the latter term being understood to include an extrusion process; for example, nylon or other synthetic filaments may be extruded in two multi-start helices of opposite hand to form a netting tube which can then be slit longitudinally and used in sheet form for the discs.

Where the discs are polygonal in shape the sides of the polygon may be straight or arcuate. The polygonal shape aforesaid permits the assembly of a disc from identical sectors suitably united at their radial edges.

With flat discs, it is convenient to thread these on a common shaft with driving spiders to which the endmost discs are

Waste water

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secured, the rest being driven through the medium of tie-rods and spaced apart either by bobbins on the latter or by means of integral flanges around the holes, through which such rods are passed.

Similar spacing means may be employed in the case of discs of dished or domed form, or alternatively the discs may be rendered self-spacing by forming them with radial, circumferential or other corrugagations or by embossing patterns thereon as in the so-called 'rigidised metal'.

Clearance of accumulated slime from the discs may be effected in known manner by mechanical scraping, and in the case of flat discs two sets may be rotated about parallel axes so that corresponding members of both sets are in mutual contact.

The invention will now be described further, by way of example only, with reference to several practical forms thereof and with reference to the accompanying drawings, in which:—

Fig. 1 is a schematic perspective view of one form of disc capable of being used in the biological treatment of waste water;

Fig. 2 is an elevation of part of a modified form of disc;

Fig. 3 is a view similar to Fig. 2 of a further modification;

Fig. 4 is a schematic sectional side elevation of a rotor;

Figs. 5 to 11 are schematic sectional views of various configurations of discs showing the manner in which such discs may be mounted in relation to each other on a rotor shaft.

Fig. 12 is a scrap view showing one way in which spacing of discs can be achieved;

Figs. 13 to 18 are schematic elevations showing a number of possible alternative ways of building up a rotor or rotor section.

Fig. 19 is a schematic elevation of a modified form of rotor shaft;

As shown in Fig. 1 a surface upon which bacterial organisms can adhere as the surface is slowly rotated whilst partially submerged in a liquid under treatment comprises a flat disc 10 of circular form which is produced from plastics material. The disc 10 is provided at its centre with a hole 11 around which is formed a boss 12 through which a shaft 13 (shown in chain line) can pass. The surface of the disc 10 is provided with a large number of small perforations 14 disposed in regular pattern so that the disc (which resembles a mesh or lattice structure) has a cellular surface for adherence of said organisms.

To produce a rotor, or a rotor section, a plurality of discs 10 identical to that described above are mounted upon the shaft 13 with the end faces of the bosses 12 in abutment so as to be closely spaced. This serves correctly to space the discs 10 on the shaft 13. To retain the discs 10 in position on the shaft 13 each boss 12 is provided with a drilled and tapped hole 15 in which is a grub screw which when screwed down will hold the disc 10 on the shaft 13 in a non-rotatable manner and in the requisite position. There are many alternative forms of disc of the kind basically referred to above.

For example the disc may be made from metal, porcelain, asbestos or rubber (the latter being produced from a rubber compound which when vulcanised will be sufficiently rigid to be self-supporting). In all of the cases referred to above the discs 10 are held non rotatably upon the shaft 13 by grub screws.

To produce the perforate or lattice form of disc 10 several alternative methods may be employed.

For example the disc surface may be provided with holes which are produced by a stamping or pressing operation when materials such as metal, plastics, asbestos or rubber are used.

Alternatively the discs, when made from metal may be produced in the manner in which expanded metal mesh is produced.

When the discs are made from rubber, plastics, porcelain or asbestos the perforations may be made by forming the discs by a moulding process.

Alternatively the discs when made from plastics material or rubber may be produced initially in tubular form by an extrusion process in which the material of the discs is extruded in the form of two series 16 and 17 of multi-start helices of opposite hand, the extruded strands of one helix becoming united to the strands of the other helix at the intersections of the strands 16, 17 to produce a lattice or netting-like tube. This tube is then slit and opened into flat form as shown in Fig. 2 and cut to produce discs with a central aperture into which is located and fixed a boss 18 adapted to receive the shaft 13. The illustration is drawn to show a lattice which in fact is disproportionately large relative to the boss 18 for the sake of clarity. It should be borne in mind that an extruded material may be formed into a mesh like structure by other methods than that just referred to and of course such materials may be used for the production of discs whether the extrusion process results in the formation of a tube which can be slit or in the form of a flat sheet from which discs can be cut.

A perforate or lattice form of disc can of course be produced by a casting process using any of the material specified above.

If desired the disc may be made by a weaving process, particularly when a metallic disc is to be produced and in such a case it may be necessary to mount the

woven metal mesh 19 between an outer ring 20 of rigid metal and an inner boss forming ring 21 to retain the woven mesh 19 in a flat condition. In such a case the discs forming a rotor or rotor section would preferably be held between end plates 22 between which, and fixed to the rings 20 are tie rods 23. In such a case the end plates 22 only are fixed non rotatably to the shaft 13 by means, for example of grub screws indicated at 24. This form of disc and part of a rotor containing such discs are shown in Figs. 3 and 4.

Whilst reference so far has been made only to the use of flat circular discs it should be borne in mind that other forms of disc may be employed. For example the discs may be square or polygonal in external contour. It is also possible to use discs which are of other than flat form. Some of the alternative forms of disc are shown in diagrammatic section in Figs. 5 to 11 and referring to Fig. 5 it can be seen that disc D of corrugated form can be arranged on the shaft 13. In this arrangement the corrugations are straight sided but, as shown in Fig. 6 discs D of corrugated form having curved corrugations may be provided.

As shown in Figs. 7 and 8 discs D of trough shape in section may be used. In Fig. 7 the discs are arranged in pairs with the troughs of a pair facing each other. Alternatively the troughs can all face in the same direction as shown in Fig. 8 so that one disc effectively partially rests within the next.

In the case illustrated in Fig. 9 the discs D are dished and are rested partially one within the other. The converse (not shown) is possible in which case the discs D are arranged in pairs with their dished faces facing each other.

As shown in Figs. 10 and 11, the discs D may be bowl shaped, in one case with one disc resting partially within the next as in Fig. 10 and in the other case with the bowls facing each other as in Fig. 11.

Reference is now made to Figs. 13 and 14 which show diagrammatically two different rotor constructions. In these illustrations the discs illustrated are indicated as being of flat form but of course they could take any of the alternative forms shown in Figs. 5 to 11 if desired.

In its simplest form the rotor consists of one module having mounted upon its shaft 13 a plurality of equispaced discs D extending over its whole length except for the end parts of the shaft which are mounted in bearings 27 and the part 13*a* of the shaft 13 which extends from one bearing 27 to be connected to a drive means not shown. The arrangement shown in Fig. 14 differs from that of Fig. 13 in that there are a plurality (for example four) of groups of discs D on the shaft 13. Between each group of discs D there is provided a space which in practice may be used to enable additional bearings 28 (one only of which is shown) adapted to support the shaft intermediate its ends.

The arrangements shown in Figs. 13 and 14 illustrate the use of discs D which are of constant size over the length of the shaft but this is not essential and some of the possible variations of this form of construction are shown diagrammatically in Figs. 15 to 18.

As shown in Fig. 15 there are mounted on the shaft 13 a series of discs D the diameter of which constantly reduce from one end of the shaft to the other between the bearings 27. In the case illustrated the disc diameters decrease towards the end 13*a* of the shaft 13 but of course the discs could be arranged in opposite manner. Additionally the discs D could be arranged in spaced apart groups as shown in Fig. 14 as opposed to being mounted over the whole length of the shaft 13.

The arrangement of Fig. 16 shows groups of discs D in which the outermost discs of a group are smallest in diameter and the centrally disposed discs are largest in diameter. The intermediate discs vary in diameter growing progressively larger from the outer discs D to the central discs D.

The converse of this disc arrangement is of course possible. Additionally whilst the groups of discs are shown in close proximity on the shaft 13 they could be spaced apart as shown in Fig. 14.

In the arrangement of Fig. 17 spaced groups of discs D are shown in which in each group the disc furthest from the end 13*a* of the shaft is smallest in diameter and the disc nearest the end 13*a* is largest in diameter. These groups of discs could be arranged in the course manner and whichever way they are arranged they could be in close proximity as opposed to being spaced along the shaft 13.

As shown in Fig. 18 there are provided groups of discs D in which one group is of "large" diameter and the next adjacent group is of "small" diameter. These groups may be in close proximity as shown or spaced apart on the shaft 13 as in the arrangement of Fig. 14.

In a modification of the arrangements so far described in which the shaft 13 has been illustrated as circular in cross section the shaft 13 could of course be of other cross section (such as square) except for those parts which are to be carried in bearings.

As shown in Fig. 19 in which no discs are shown the shaft 13 need not be continuous. In fact there may be provided a sectional shaft arrangement in which each

section 29 is carried by bearings 30 and between each adjacent section 29 in such an arrangement there is provided a drive connection comprising a pair of gear pinions 31. These pinions 31 may be of the same size and number of teeth to give a 1 to 1 gear ratio or they may be of different sizes and numbers of teeth to give either an increase or decrease in gear ratio between shaft sections 29. One outer shaft section 29 is provided with an extension 29*a* to which drive can be applied from a source of power (not shown). Any one of the various form of disc may be used on any one or more of the shaft sections 29.

Whilst reference has been made above to the fixing of the rotor discs in their correct spacing by the provision of bosses (see Fig. 1) adapted to be clamped onto the shaft or by the use of tie rods extending between end plates (see Fig. 4) it is possible to space the discs by other means.

One such possibility is illustrated in Fig. 12 and consists of providing on each disc D at a position adjacent its periphery and at one face of the disc a substantially spherical recess 32 which is open at the face of the disc. At the opposite face of the disc is provided a stem 33 having a spherical bead 34 at its free end. As shown in the drawing the discs can be held in correct spacing by pressing the bead 34 of one disc into the recess of the next adjacent disc. Conveniently and to ensure correct spacing over the whole of the discs a plurality of such beads and recesses are provided at spaced intervals around the peripheral region of the discs.

Other forms of spacing can be achieved by means not shown in the drawings. For example, when using expanded polystyrene it is possible to form the discs with integral spacers in the form of protrusions on one face or on both faces of the discs. Alternatively if cup like, or part conical protrusions are formed on the discs they will act as spacers. In such cases when the discs are threaded onto a shaft the protrusions are aligned and a spindle or the like is passed through the discs, preferably at the protrusions to prevent relative rotation of the discs and thus loss of spacing. The procedure is adopted when the spacing formations are not at the centre of the discs. In the case in which the spacing formations are at the disc centres the shaft will hold the disc spacers in position to retain the spacing and it will be necessary only to clamp the discs on the shaft by the use of clamping rings, spiders or the like at the ends of the disc assembly. Spacing in any one of the possible forms including the forming of protrusions is capable of use when the discs are made from foamed materials which are relatively rigid when the foam is gelled or cured.

WHAT WE CLAIM IS:—

1. Apparatus for the biological treatment of waste water by the biosorption process, comprising a rotor for partially immersing in the waste water so that bacterial organisms from the water adhere to the surface of the rotor and are therefore, with rotation of the rotor, alternately exposed to air and re-immersed in the water, wherein said rotor is structured to provide a plurality of closely spaced co-axial discs, having a cellular surface, for the adherence of said organisms.

2. Apparatus as claimed in claim 1 in which the discs have a cellular surface derived from perforations at regular or irregular spacing, such discs being of circular polygonal or other regular profile and being either flat, dished or corrugated.

3. Apparatus as claimed in claim 1 in which the rotor comprises a sheet of imperforate material such as expanded polystyrene, foamed plastics material or the like, which may be rigid or flexible and of open or closed cell form.

4. Apparatus as claimed in claim 1 in which the discs of the rotor are produced from metal, synthetic plastics, asbestos, felt, rubber or of porcelain.

5. Apparatus as claimed in claim 2 in which the discs are perforate over part at least of the surface thereof.

6. Apparatus as claimed in claim 2 in which the discs are produced from metal, synthetic plastics or rubber material, and by slitting the material of the discs and expanding the said material to render them perforate.

7. Apparatus as claimed in claimed in claim 1 in which the discs are formed from an inherently flexible material such as felt, the said material being held in tension within relatively rigid rims or frame elements.

8. Apparatus as claimed in claim 2 in which the discs are formed by casting or moulding the latter term being understood to include an extrusion process.

9. Apparatus as claimed in claim 8 in which the moulding involves extrusion in two multi-start helices of opposite hand to form a netting tube which is then slit longitudinally and used in sheet form.

10. Apparatus as claimed in claim 1 in which the discs are of circular profile, or are square, or in the form of a regular polygon with straight or arcuate sides.

11. Apparatus as claimed in claim 10 in which the discs, when in the form of a regular polygon are each built up from segments united along radially disposed edges of the segments.

12. Apparatus as claimed in claim 1 in which the discs are flat and are threaded

upon a common shaft with driving spiders to which the end-most discs are secured, the rest being driven through the medium of tie-rods and spaced apart either by bobbins on the latter or by means of integral flanges around the holes, through which such rods are passed.

13. Apparatus as claimed in claim 1 in which the discs are flat and are held in spaced relation on a shaft by means of bosses formed centrally of the discs and extending from one face at least thereof.

14. Apparatus as claimed in claim 2 in which the discs are spaced by forming them with radial, circumferential or other corrugations or by embossing patterns thereon as in the so called 'rigidised metal'.

15. Apparatus as claimed in any one of the preceding claims in which the rotor has a shaft of unitary form and the shaft is adapted to be supported at its ends in bearings, one end thereof being connectable to drive means.

16. Apparatus as claimed in any one of the preceding claims 1 to 14 in which the rotor has a shaft composed of a plurality of parallel parts, adjacent parts being connected by gears.

17. Apparatus as claimed in claim 1 in which the discs are of constant size over the whole rotor.

18. Apparatus as claimed in claim 1 in which the discs are of varying size.

19. Apparatus as claimed in claim 18 in which the discs decrease in size regularly over the whole rotor from one end thereof.

20. Apparatus as claimed in claim 18 in which the discs are arranged to increase and decrease in size stepwise over the whole rotor.

21. Apparatus as claimed in claim 1 in which the discs are located in spaced groups over the whole rotor, there being bearing means between some at least of the groups of discs.

22. Apparatus as claimed in claim 1 in which adjacent discs are secured in spaced relationship by means of the interengagement of spherical formations of one disc engaging in spherical depressions or apertures in an adjacent disc.

23. Apparatus according to claim 1 including a rotor arranged substantially as hereinbefore described with reference to any one of Figs. 1 to 19 of the accompanying drawings.

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1324358 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1.

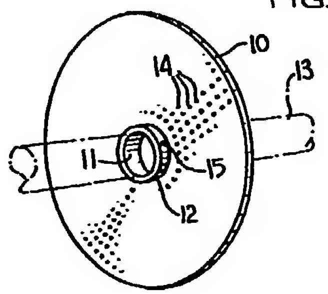
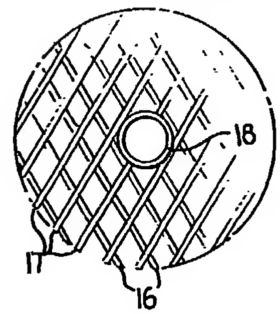


FIG. 2.



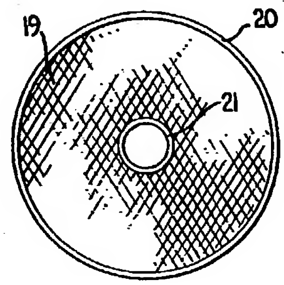
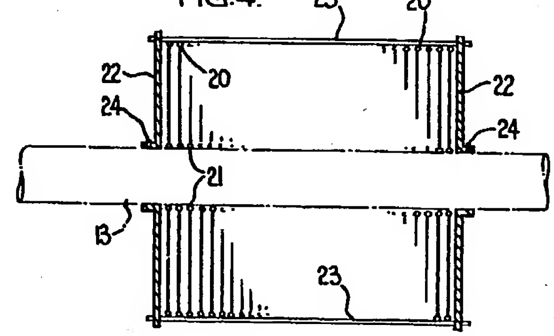


FIG. 3.

FIG. 4.



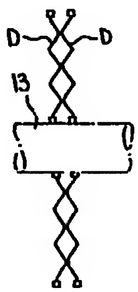


FIG. 5.

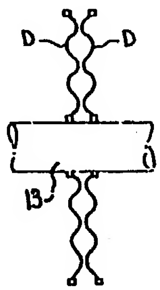


FIG. 6.

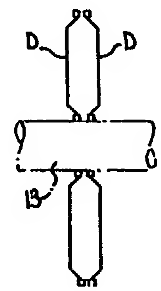


FIG. 7.

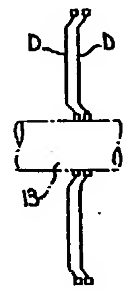


FIG. 8.

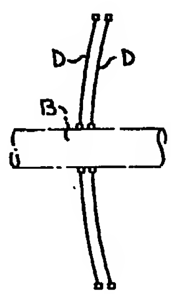


FIG. 10.

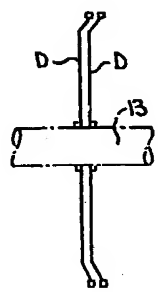


FIG. 9.

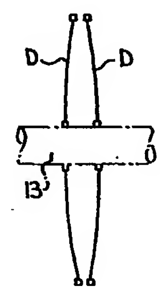


FIG. 11.

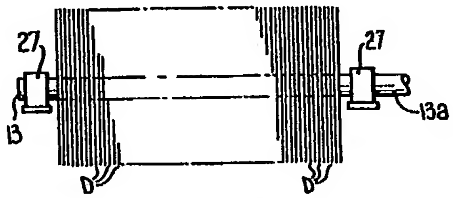


FIG.13.

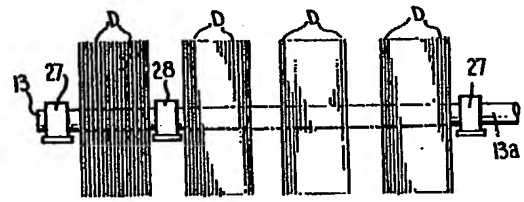


FIG.14.

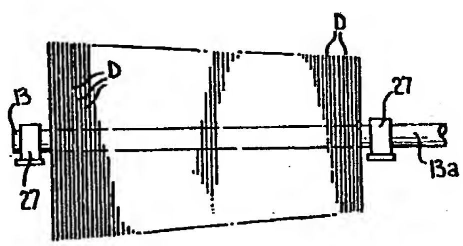


FIG.15.

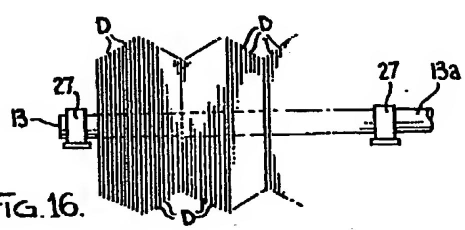


FIG.16.

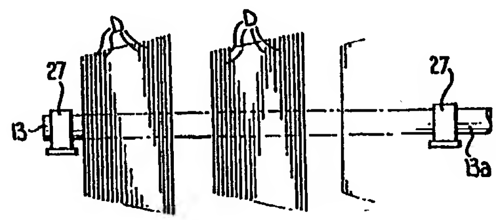


FIG.17.

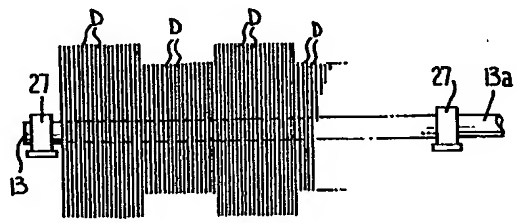


FIG.18.

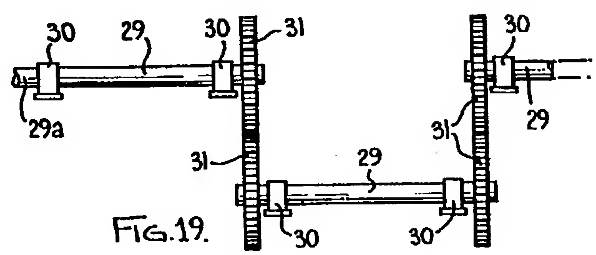


FIG.19.

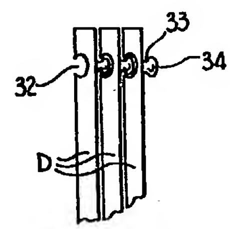


FIG.12